

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. **(currently amended)** An apparatus for online signature verification using ~~analyzing~~ a reference signature database (DB) ~~of a specific user~~, the apparatus comprising:

a signature data input unit for digitalizing a locus of a user's input signature and reading the digitized locus as a signature sequence of sample points sampled at regular time intervals;

a first pattern transform unit for performing a speed equalization on the signature sequence read by the signature data input unit and generating a first transformed pattern sequence, wherein said speed equalization is based on the assumption that linear velocities at the sample points on the locus are equal to a constant value;

a second pattern transform unit for performing a velocity transformation on the signature sequence read by the signature data input unit and generating a second transformed pattern sequence;

a feature extraction unit for extracting a characteristics vector ~~three feature vectors~~ from the signature sequence ~~read by the signature data input unit~~, the first transformed pattern sequence ~~transformed by the first pattern transform unit~~ and the second transformed pattern sequence ~~transformed by the second pattern transform unit~~, respectively, ~~to thereby generate the three feature vectors having different information;~~

a difference vector estimation unit for generating a difference vector between ~~[[the]]~~ a feature vector of the ~~specific~~ user's reference signature read from the reference signature DB and the characteristics ~~feature~~ vector extracted by the feature extraction unit; and

a determination unit for determining whether ~~[[an]]~~ the input signature and the reference signature are signed by the same a single person or not, based on the difference vector generated from the difference vector estimation unit.

2. **(currently amended)** The apparatus of claim 1, wherein ~~the first pattern transform unit transforms the signature sequence read by the signature data input unit and generates the first transformed pattern sequence,~~ the speed equalization is transform being performed by using ~~[[a]]~~ the following equation:

~~(Equation)~~

$$\begin{aligned} s_i &= p_i & i &= 1, 2 \\ s_i &= s_{i-1} + (p_i - p_{i-1}) & i &= N-1, N \\ s_i &= s_{i-1} + v\Delta t \bullet \Theta & & \text{otherwise} \end{aligned}$$

wherein ~~p_i , s_i , v , Δt , and Θ represent a point on an input signature pattern locus, s_i is an element of a transformed two dimensional vector list, a velocity, a time interval between sample points, and a unit vector in the direction of θ , i.e., in the locus at the point p_i , respectively~~

p_i represents the i^{th} sample point on the signature sequence of the digitized locus,

s_i represents the corresponding i^{th} element of the first transformed pattern sequence,

v represents the constant velocity,

Δt represents the sampling time interval between the sample points on the signature sequence, and

Θ represents a unit vector in the direction θ of the digitized locus at the sample point p_i .

3. **(currently amended)** The apparatus of claim 1, wherein ~~the second pattern transform unit transforms the signature sequence read by the signature data input unit and generates the second transformed pattern sequence,~~ the velocity transformation is [[being]] performed by using ~~[[a]]~~ the following equation:

~~(Equation)~~

$$\begin{aligned} v_i &= v_3 & i &= 1, 2 \\ v_i &= v_{N-2} & i &= N-1, N \\ v_i &= (v_{xi}, v_{yi}) & & \text{otherwise} \end{aligned}$$

wherein [[the]]

v_i is the i^{th} element of the second transformed pattern sequence ~~an element of the transformed two-dimensional vector list, and~~

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the corresponding sample point p_i on the digitized input signature pattern locus.

4. **(currently amended)** The apparatus of claim 1, wherein the speed equalization is a technique for recomposing a signature pattern based on an inverse proportional relation between a signature speed and a length of the pattern, and the velocity transformation is a technique for transforming a spatial pattern into a velocity domain.

5. **(currently amended)** ~~An method for~~ online signature verification method using ~~analyzing~~ a reference signature DB ~~of a specific user~~, the method comprising the steps of:

(a) digitalizing a locus of a user's input signature and reading the digitized locus as a signature sequence of sample points sampled at regular time intervals;

(b) performing a speed equalization on the signature sequence read in the step (a) to generate a first transformed pattern sequence, wherein said speed equalization is based on the assumption that linear velocities at the sample points on the locus are equal to a constant value;

(c) performing a velocity transformation on the signature sequence read in the step (a) to generate a second transformed pattern sequence;

(d) extracting a characteristics vector ~~three characteristics vectors~~ from the signature sequence read in the step (a), the first transformed pattern sequence generated ~~transformed~~ in the step (b) and the second transformed pattern sequence generated ~~transformed~~ in the step (c); ~~respectively, to thereby generate three characteristics vectors having different information;~~

(e) generating a difference vector between a feature ~~the characteristics~~ vector of the ~~specific~~ user's reference signature read from the reference signature DB and the characteristics vector extracted in the step (d); and

(f) determining whether ~~[[an]]~~ the input signature and the reference signature are signed by the same ~~a single~~ person or not, based on the difference vector generated in the step (e).

6. **(new)** The method of claim 5, wherein the speed equalization is performed by using the following equation:

$$\begin{array}{ll} s_i = p_i & i = 1, 2 \\ s_i = s_{i-1} + (p_i - p_{i-1}) & i = N-1, N \\ s_i = s_{i-1} + v\Delta t \bullet \Theta & \text{otherwise} \end{array}$$

wherein

p_i represents the i^{th} sample point on the signature sequence of the digitized locus,

s_i represents the corresponding i^{th} element of the first transformed pattern sequence,

v represents the constant velocity,

Δt represents the sampling time interval between the sample points on the signature sequence, and

Θ represents a unit vector in the direction θ of the digitized locus at the sample point p_i .

7. **(new)** The method of claim 5, wherein the velocity transformation is performed by using the following equation:

$$\begin{array}{ll} v_i = v_3 & i = 1, 2 \\ v_i = v_{N-2} & i = N-1, N \\ v_i = (v_{xi}, v_{yi}) & \text{otherwise} \end{array}$$

wherein

v_i is the i^{th} element of the second transformed pattern sequence, and

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the corresponding sample point p_i

on the digitized locus.

8. **(new)** The method of claim 5, wherein the speed equalization is a technique for recomposing a signature pattern based on an inverse proportional relation between a signature speed and a length of the pattern, and the velocity transformation is a technique for transforming a spatial pattern into a velocity domain.

9. **(new)** The method of claim 6, wherein the direction θ of the digitized locus at the sample point p_i is determined by the following equation:

$$\theta = \arctan(v_{yi}/v_{xi})$$

wherein

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the sample point p_i .

10. **(new)** The method of claim 9, wherein the velocity transformation is performed by using the following equation:

$$\begin{aligned} v_i &= v_3 & i &= 1, 2 \\ v_i &= v_{N-2} & i &= N-1, N \\ v_i &= (v_{xi}, v_{yi}) & & \text{otherwise} \end{aligned}$$

wherein

v_i is the i^{th} element of the second transformed pattern sequence.

11. **(new)** The method of claim 10, wherein the first horizontal and vertical derivatives at the sample point p_i are determined by the following equations:

$$\begin{aligned} v_{xi} &= (-p_{i+2}(x) + 8p_{i+1}(x) - 8p_{i-1}(x) + p_{i-2}(x))/12 \\ v_{yi} &= (-p_{i+2}(y) + 8p_{i+1}(y) - 8p_{i-1}(y) + p_{i-2}(y))/12. \end{aligned}$$

12. **(new)** The method of claim 5, wherein the sample points are distributed according

to a radial histogram which comprises bins successively arranged around the origin of a Cartesian coordinate system, and wherein the distribution is based on locations where the locus passes.

13. **(new)** The apparatus of claim 2, wherein the direction θ of the digitized locus at the sample point p_i is determined by the following equation:

$$\theta = \arctan(v_{yi}/v_{xi})$$

wherein

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the sample point p_i .

14. **(new)** The apparatus of claim 13, wherein the velocity transformation is performed by using the following equation:

$$\begin{aligned} v_i &= v_3 & i &= 1, 2 \\ v_i &= v_{N-2} & i &= N-1, N \\ v_i &= (v_{xi}, v_{yi}) & & \text{otherwise} \end{aligned}$$

wherein

v_i is the i^{th} element of the second transformed pattern sequence.

15. **(new)** The apparatus of claim 14, wherein the first horizontal and vertical derivatives at the sample point p_i are determined by the following equations:

$$\begin{aligned} v_{xi} &= (-p_{i+2}(x) + 8p_{i+1}(x) - 8p_{i-1}(x) + p_{i-2}(x))/12 \\ v_{yi} &= (-p_{i+2}(y) + 8p_{i+1}(y) - 8p_{i-1}(y) + p_{i-2}(y))/12. \end{aligned}$$

16. **(new)** The apparatus of claim 1, wherein the sample points are distributed according to a radial histogram which comprises bins successively arranged around the origin of a Cartesian coordinate system, and wherein the distribution is based on locations where the locus passes.